

Synthesis and Characterization of Plant Derived Silver Nanoparticles Using UV-VIS Spectroscopy

Vonteru Muni Sekhar^{*1}, M. Aparna², P. Hemanth², G. Suryanarayana², G. Manasa², G. Balaji²

¹Associate Professor, Department of Pharmaceutical Analysis, Vagdevi College of Pharmacy and Research Centre, Brahmadevam(V), Muthukur (M), Nellore-524346, A.P, India.

²IVth Year B.Pharm student, Vagdevi College of Pharmacy and Research Centre, Brahmadevam(V), Muthukur (M), Nellore-524346, A.P, India.

***Corresponding E-mail:** munisekhar0003@gmail.com

Received: 19-01-2026 | Revised: 07-02-2026 | Accepted: 17-02-2026 | Published: 28-02-2026

Abstract:

The present study focuses on the green synthesis, characterization, and evaluation of silver nanoparticles (AgNPs) using plant extracts of *Azadirachta indica* (Neem) leaves and *Acorus calamus* rhizomes. Green nanotechnology offers an eco-friendly, cost-effective, and sustainable alternative to conventional physical and chemical nanoparticle synthesis methods, which often involve toxic chemicals and high energy consumption. In this study, aqueous extracts of both plants were prepared and utilized as reducing and stabilizing agents for the synthesis of silver nanoparticles from silver nitrate solution. The formation of nanoparticles was initially indicated by a visible color change from pale yellow to brown, confirming the reduction of Ag ions to Ag. The synthesized nanoparticles were characterized using UV-Visible spectroscopy, which revealed distinct Surface Plasmon Resonance (SPR) peaks at approximately 421 nm for *Azadirachta indica* and 384 nm for *Acorus calamus*, confirming successful nanoparticle formation. Comparative analysis demonstrated that *Azadirachta indica* exhibited superior reducing ability, faster synthesis rate, and greater stability of nanoparticles compared to *Acorus calamus*. More than 90% reduction of silver ions occurred within 4 hours, indicating rapid nanoparticle formation. The enhanced efficiency of neem extract is attributed to the presence of phytochemicals such as flavonoids, phenolics, and terpenoids, which play a crucial role in reduction and stabilization processes. The study concludes that plant-mediated synthesis of silver nanoparticles is an effective and environmentally benign approach with significant potential for antimicrobial and biomedical applications. The findings highlight the importance of phytoconstituents in nanoparticle synthesis and suggest further exploration for large-scale production and therapeutic applications.

Keywords: Green synthesis, Silver nanoparticles, *Azadirachta indica*, *Acorus calamus*, Surface Plasmon Resonance, Phytochemicals, Antimicrobial activity, Nanotechnology, UV-Visible spectroscopy, Eco-friendly synthesis

Introduction

Nanotechnology is fundamentally changing the way in which materials are synthesized and devices are fabricated. Incorporation of nanoscale building blocks into functional assemblies and further into multifunctional devices can be achieved through a “bottom-up approach”. Metal nanoparticles have a high specific surface area and a high fraction of surface atoms. Because of the unique physicochemical characteristics of nanoparticles, including catalytic activity, optical properties, electronic properties, antibacterial properties, and magnetic properties [1-7] they are gaining the interest of scientist for their novel methods of synthesis. The term “nanoparticles” is used to describe a particle with size in the range of 1nm- 100nm, at least in one of the three possible dimensions. In this size range, the physical, chemical and biological properties of the nanoparticles changes in fundamental ways from the properties of both individual atoms/molecules and of the corresponding bulk materials. Nanoparticles can be made of materials of diverse chemical nature, the most common being metals, metal oxides, silicates, non-oxide ceramics, polymers, organics, carbon and biomolecules. Nanoparticles exist in several different morphologies such as spheres, cylinders, platelets, tubes etc. Generally the nanoparticles are designed with surface

modifications tailored to meet the needs of specific applications they are going to be used for. The enormous diversity of the nanoparticles (Figure.1) arising from their wide chemical nature, shape and morphologies, the medium in which the particles are present, the state of dispersion of the particles and most importantly, the numerous possible surface modifications the nanoparticles can be subjected to make this an important active field of science now-a-days[8-10].

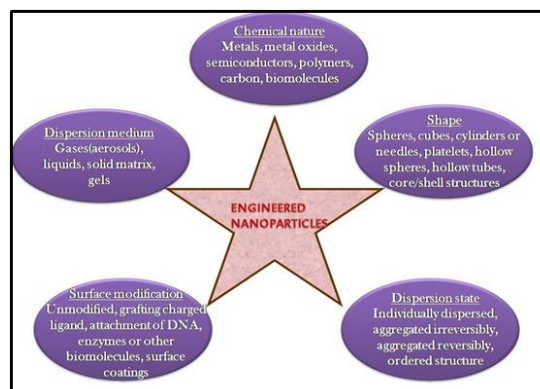


Fig.1: Various features contributing to the diversity of engineered nanoparticles

Materials and Methods

Collection and Authentication of Plant Materials

Fresh leaves of *Azadirachta indica* (Neem) were collected from the local campus area, and rhizomes of *Acorus calamus* (Sweet flag) were procured from a reliable herbal supplier. The collected plant materials were authenticated by Dr. K. Madhava Chetty, Assistant Professor, Dept. of Botany, S V University, Tirupati. The samples were cleaned thoroughly with distilled water to remove dust, soil, and other contaminants, and then air-dried under shade to preserve their phytoconstituents[11-15].

Preparation of Plant Extract

Neem Leaves Extract

The collected neem leaves were washed several times with distilled water and shade-dried. The dried leaves were then powdered using a mechanical grinder. About 1% (w/v) of the powdered material was mixed with deionized water in a 250 mL conical flask and incubated for 30 minutes at room temperature. The mixture was centrifuged at 5000 rpm for 30 minutes, and the supernatant was collected and filtered using Whatman filter paper. The clear filtrate was used as the reducing and stabilizing agent for nanoparticle synthesis.

Acorus calamus Rhizome Extract

The dried rhizomes of *Acorus calamus* were powdered and processed similarly. Approximately 1% (w/v) of the powder was mixed with deionized water and incubated for 30 minutes. The mixture was centrifuged at 5000 rpm for 30 minutes, followed by filtration to obtain a clear extract. This extract was used for nanoparticle synthesis.

Preparation of Silver Nanoparticles (Green Synthesis)

Silver nanoparticles were synthesized using aqueous plant extracts as reducing agents. A 1 mM solution of silver nitrate (AgNO_3) was prepared. Different ratios of plant extract to silver nitrate solution (30:1, 60:1, 120:1, and 240:1) were prepared by varying the concentration of plant extract. To each prepared extract, 0.17% of 1 mM AgNO_3 solution was added and mixed thoroughly. The reaction mixture was incubated at room temperature. Formation of silver nanoparticles was indicated by a visible color change from pale yellow to brown due to surface plasmon resonance. The synthesized colloidal solution was then used for further characterization[16-19].

UV-Visible Spectroscopic Analysis: The formation and optical properties of synthesized silver nanoparticles were analyzed using a UV-Visible spectrophotometer (Perkin-Elmer Lambda 35, Germany) [20-21].

- The reaction mixtures were scanned at different time intervals up to 24 hours.
- Spectral analysis was carried out in the wavelength range of 350–500 nm.
- The characteristic Surface Plasmon Resonance (SPR) peak confirmed nanoparticle formation.
- Absorbance maxima were observed around:
 - ~421 nm for *Azadirachta indica*
 - ~384 nm for *Acorus calamus*

Mechanism Insight (Based on UV-Vis Observation)

The color change observed during synthesis is attributed to Surface Plasmon Resonance (SPR), which arises due to collective oscillation of electrons in silver nanoparticles when exposed to light. The position and intensity of the SPR peak provide information regarding particle size, shape, and stability.

Results and Discussion

Synthesis of Silver Nanoparticles

Upon addition of silver nitrate (AgNO_3) solution to the plant extracts, a noticeable color change was observed:

- From pale yellow to brown in case of *Azadirachta indica*
- From light yellow to dark brown in case of *Acorus calamus*
- This color change is a primary indication of the formation of silver nanoparticles due to the reduction of Ag^+ ions into Ag^0 . The intensity of the color increased with time, suggesting progressive nanoparticle formation.
- Among different ratios (30:1, 60:1, 120:1, 240:1), it was observed that higher extract concentration facilitated faster reduction, indicating the significant role of phytochemicals in nanoparticle synthesis.

UV-Visible Spectroscopic Analysis

The formation of silver nanoparticles was confirmed using UV-Visible spectroscopy. The spectra were recorded in the wavelength range of 350–500 nm at different time intervals.

UV-Vis Spectrophotometer Analysis:

The metal nanoparticles have free electrons, which give the SPR absorption band, due to the combined vibration of electrons of metal nanoparticles in resonance with light wave. The sharp bands of silver nanoparticles were observed around 421 nm in case of *Azadirachta indica* whereas the bands for *Acorus calamus* were observed around 384 nm. From different literatures it was found that the silver nanoparticles show SPR peak at around 420 nm. From our studies we found the SPR peak for *Azadirachta indica* at 421 nm whereas for *Acorus calamus* it was at 384 nm [22-24]. So we confirmed that *Azadirachta indica* leaf extract has more potential to reduce Ag^+ ions into Ag nanoparticles than *Acorus calamus* extract, which lead us for further research on synthesis of silver nanoparticles from *Azadirachta indica* leaf extracts. The intensity of absorption peak increases with increasing time period.

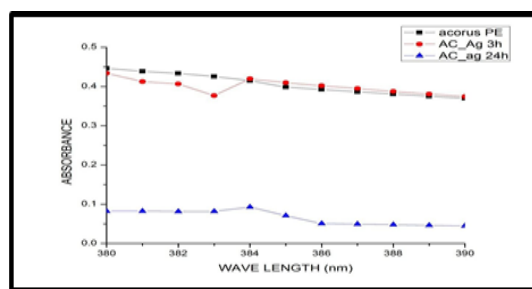


Fig.2: UV-vis spectra of *Acorus Calamus* at different time interval

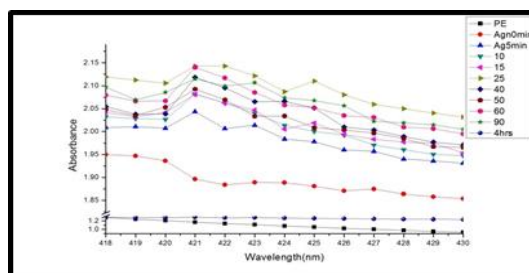


Fig.3: UV-VIS spectra of *Azadirachta indica* 30:1 ratio at different time interval

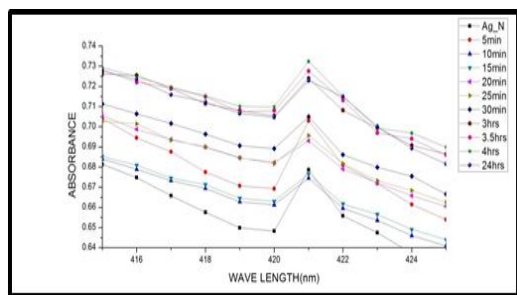


Fig.4: Fig.3: UV-VIS spectra of *Azadirachta indica* 60:1 ratio at different time interval

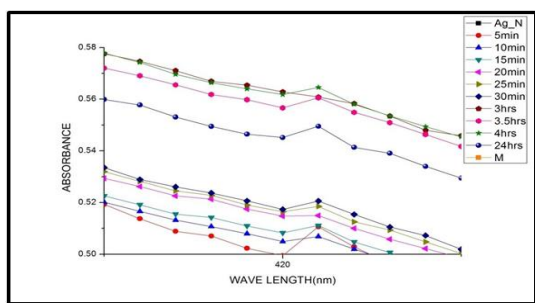


Fig.5: UV-vis spectra of *Azadirachta indica* 120:1 ratio at different time interval

Discussion

The present study was carried out to synthesize and characterize silver nanoparticles using plant-mediated green synthesis employing *Azadirachta indica* (Neem) leaves and *Acorus calamus* rhizomes. The plant materials were collected, authenticated, and processed to obtain aqueous extracts rich in phytochemicals such as flavonoids, phenolics, and terpenoids, which play a vital role in nanoparticle synthesis. The prepared plant extracts were utilized as reducing and stabilizing agents for the synthesis of silver nanoparticles using silver nitrate (AgNO_3). Different ratios of plant extract to metal ion solution (30:1, 60:1, 120:1, and 240:1) were investigated. The formation of nanoparticles was initially confirmed by a visible color change from pale yellow to brown, indicating the reduction of silver ions (Ag^+) to metallic silver (Ag^0). The synthesized nanoparticles were characterized using UV-Visible spectroscopy. The spectral analysis revealed distinct Surface Plasmon Resonance (SPR) peaks at approximately 421 nm for *Azadirachta indica* and 384 nm for *Acorus calamus*, confirming the formation of silver nanoparticles. The increase in absorbance intensity over time indicated continuous nanoparticle formation and stabilization. Comparative analysis demonstrated that *Azadirachta indica* extract exhibited superior reducing capacity, faster reaction kinetics, and greater nanoparticle stability compared to *Acorus calamus*. The rapid reduction (over 90% within 4 hours) and sustained stability for several weeks highlighted the efficiency of the green synthesis method. The study confirmed that phytochemicals present in plant extracts not only facilitate the reduction of metal ions but also act as capping agents, preventing aggregation and ensuring stability of nanoparticles.

Conclusion

The present investigation successfully demonstrated the green synthesis of silver nanoparticles using aqueous extracts of *Azadirachta indica* leaves and *Acorus calamus* rhizomes. The

study established that plant-mediated synthesis is a simple, cost-effective, and environmentally friendly alternative to conventional physical and chemical methods. The formation of silver nanoparticles was confirmed through UV-Visible spectroscopic analysis, with characteristic SPR peaks observed in the expected range. Among the two plant extracts studied, *Azadirachta indica* showed higher efficiency in reducing silver ions, producing nanoparticles with better stability and stronger optical properties. The results clearly indicate that the phytoconstituents present in plant extracts play a dual role as reducing as well as stabilizing agents. The nanoparticles synthesized were stable over time, suggesting their potential applicability in various biomedical and pharmaceutical fields. Overall, this study highlights the potential of green nanotechnology as a sustainable approach for nanoparticle synthesis. Further studies involving advanced characterization techniques and biological evaluations can provide deeper insights into their applications.

Acknowledgment

The authors thank the, Vagdevi College of Pharmacy and Research Centre, Nellore, Andhra Pradesh, India, for technical assistance and support.

Conflict of Interests

The authors declare no conflict of interest

Ethics Approval

Not applicable

Funding

This study received no specific funding from public, commercial, or not for profit funding agencies.

AI Tool Declaration

The authors declare that no AI and related tools are used to write the scientific content of this manuscript.

Data Availability

Data will be available on request

References

- [1] Harekrishna Bar, D.K.B., Gobinda sahu P, priyanka Sarkar, Sankar PD., "Green synthesis of silvernanoparticles using latex of *Jatropha curcas*.". Colloid surface A, 2009. 39(3): p. 134-139.
- [2] Cassandra D, N.N., Jodi H, Linfeng G, Tan, Li, et al. , "Green synthesis of gold and silver nanoparticles from plant extracts.".
- [3] Kaviya S, S.J., Viswanathan B., "Green Synthesis of silver nanoparticles using *Polyalthia longifolia* Leaf extract along with *D-Sorbitol*.". Journal of nanotechnology, 2011: p. 1-5.
- [4] Catauro M, R.M., De Gaaetano FD, Marotta A, "Sol-gel processing of drug delivery materials and release kinetics.". J Mater Sci Mater Med, 2005. 16(3): p. 261-265.

- [5] Crabtree JH, B.R., Siddiqi Ra, Huen IT, Handott LL, Fishman A, "The efficacy of silver-ion implanted catheters in reducing peritoneal dialysis-related infections.". *Perit Dial Int*, 2003. 23(4): p. 368-374.
- [6] Krolukowska A, K.A., Michota A, Bukowska J, "SERS studies on the structure of thioglycolic acid monolayers on silver and gold.". *Surf Sci*, 2003. 532: p. 227- 232.
- [7] Zhao G, S.J., "Multiple parameters for the comprehensive evaluation of the susceptibility of *Escherichia coli* to the silver ion.". *Biometals*, 1998. 11: p. 27.
- [8] Jiang H, M.S., Wong ACL, Denes FS, "Plasma enhanced deposition of silver nanoparticles onto polymer and metal surfaces for the generation of antimicrobial characteristics.". *J Appl Polym Sci*, 2004. 93: p. 1411-1422.
- [9] Duran N, M.P., Alves OL, De Souza GIH, Esposito E, "Mechanistic aspects of biosynthesis of silver nanoparticles by several *Fusarium oxysporum* strains.". *J Nanobiotechnol*, 2005. 3: p. 8-14.
- [10] RO, B., "Silver ions in the treatment of local infections.". *Met Based Drugs*, 1999. 6: p. 297-300.
- [11] Klaus T, J.R., Olsson E, Granqvist C-G, "Silverbased crystalline nanoparticles, microbially fabricated.". *Proc Natl Acad Sci USA*, 1999. 96: p. 13611-13614.
- [12] Garima Singhal , R.B., Kunal Kasariya , Ashish Ranjan Sharma , Rajendra Pal Singh, "Biosynthesis of silver nanoparticles using *Ocimum sanctum* (Tulsi) leaf extract and screening its antimicrobial activity.". *J Nanopart Res*, 2011. 13: p. 2981-2988.
- [13] Mukherjee P, A.A., Mandal DS, Senapati S, Sainkar R, Khan MI, Parishcha R, Ajaykumar PV, Alam M, Kumar R, Sastry M, "Fungus-mediated synthesis of silver nanoparticles and their immobilization in the mycelial matrix: a novel biological approach to nanoparticle synthesis.". *Nano Lett*, 2001. 1: p. 515-519.
- [14] Spring H, S.K., "Diversity of magnetotactic bacteria.". *Syst Appl Microbiol*, 1995. 18(2): p. 147-153.
- [15] Sastry M, A.A., Islam NI, Kumar R., "Biosynthesis of metal nanoparticles using fungi and actinomycetes.". *Current Sc.*, 2003. 85(2): p. 162-170.
- [16] Sastry M, A.A., Khan MI, Kumar R., "Microbial nanoparticle production in Nanobiotechnology.". *Nanobiotechnology*, 2003. 85(2): p. 163-169.
- [17] Nelson D, P.D., Oswaldo LA, Gabriel IHDS, Elisa E., "Mechanical aspects of biosynthesis of silver nanoparticles by several *Fusarium oxysporum* strains.". *Journal of Nanobiotechnology*, 2005. 3: p. 8.
- [18] Hemanth NKS, K.G., Karthik L, Bhaskara RKV., "Extracellular biosynthesis of silver nanoparticles using the filamentous fungus *Penicillium sp.*". *Arch Appl Sci Res*, 2010. 2(6): p. 161-167. Natarajan K, S.S., Ramchandra M., "Microbial production of silver nanoparticles. *Dig J Nanomat Bios*, 2010. 5(1): p. 135-140.
- [19] Elumalai EK, P.T., Hemachandran J, Vivivan Therasa S, Thirumalai T, David E., "Extracellular synthesis of silver nanoparticles using leaves of *Euphorbia hirta* and their antibacterial activities.". *J Phram Sci*, 2010. 2(9): p. 549-554.
- [20] Ankamwar B, D.C., Ahmad A, Sastry M., "Biosynthesis of gold and silver nanoparticles using *Emblics Officinalis* Fruit extract and their Phase Transfer and Transmetallation in an Organic Solution.". *J nanosci nanotechnol*, 2005. 5(10): p. 1665-1671.
- [21] Kasthuri J, K.K., Rajendran N., "Phyllanthin assisted biosynthesis of silver and gold nanoarticles a novel biological approach.". *J Nanopart Res*, 2009. 11: p. 1075-1085.
- [22] Vijayaraghavan K, K.N.S., Udaya Prakash N, Madhankumar D., "Biomimetic synthesis of silver nanoparticles by aqueous extract of *Syzygium aromaticum*". *Colloids Surf B Biointerfaces*, 2012. 75: p. 33-35.
- [23] Amarendra DD, K.G., "Biosynthesis of silver and gold nanoparticles using *Chenopodium album* leaf extract.". *Colloid Surface A*, 2010. 369(3): p. 27-33.
- [24] Guidelli EJ, R.M., Zaniquelli D, Baffa O., "Green synthesis of colloidal silver nanoparticles using natural rubber latex extracted from *Hevea brasiliensis*". *Mol Biomol Spectrosc*, 2011. 82(1): p. 140-145.